Kinsbursky Brothers
Integrated Recycling Solutions

RETRIEV
TECHNOLOGIES

Lessons from recycling multiple types of batteries.

Public Workshop on Lead-acid Batteries and Alternatives.

November 6, 2017

AGENDA

- Brief Company History

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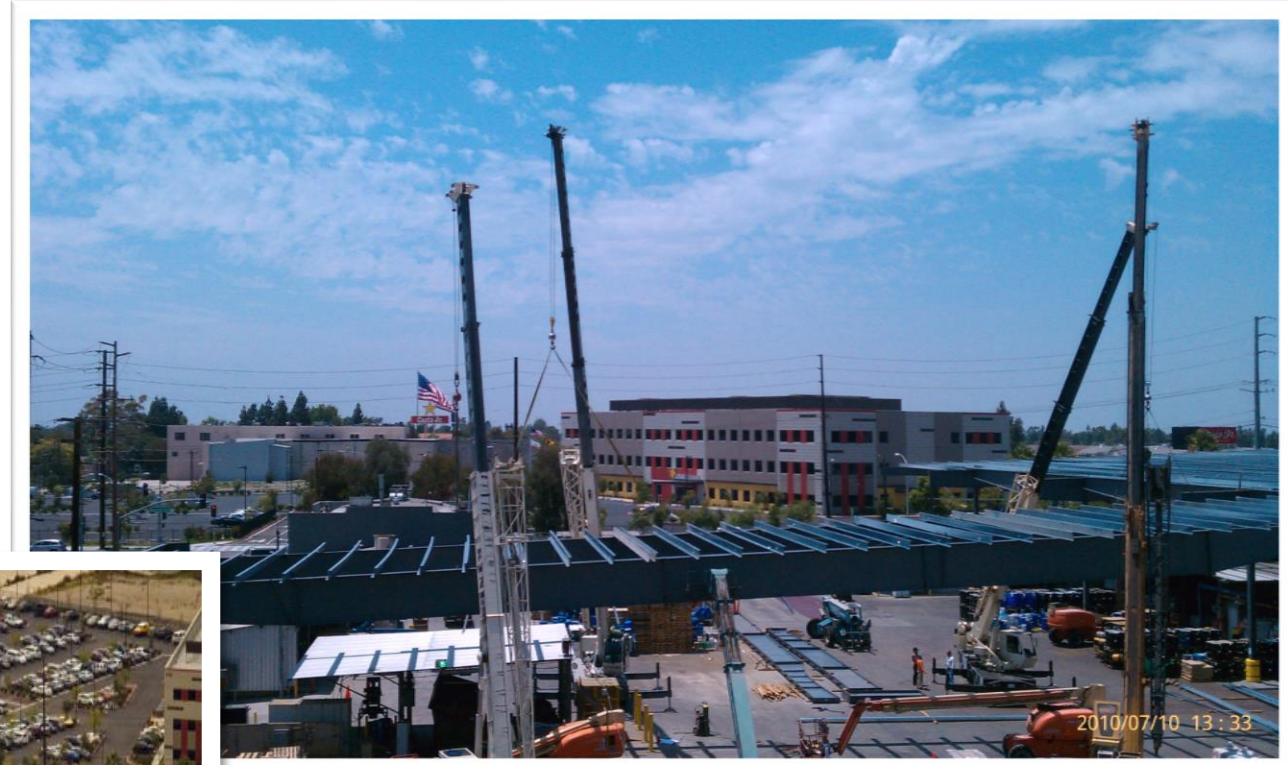
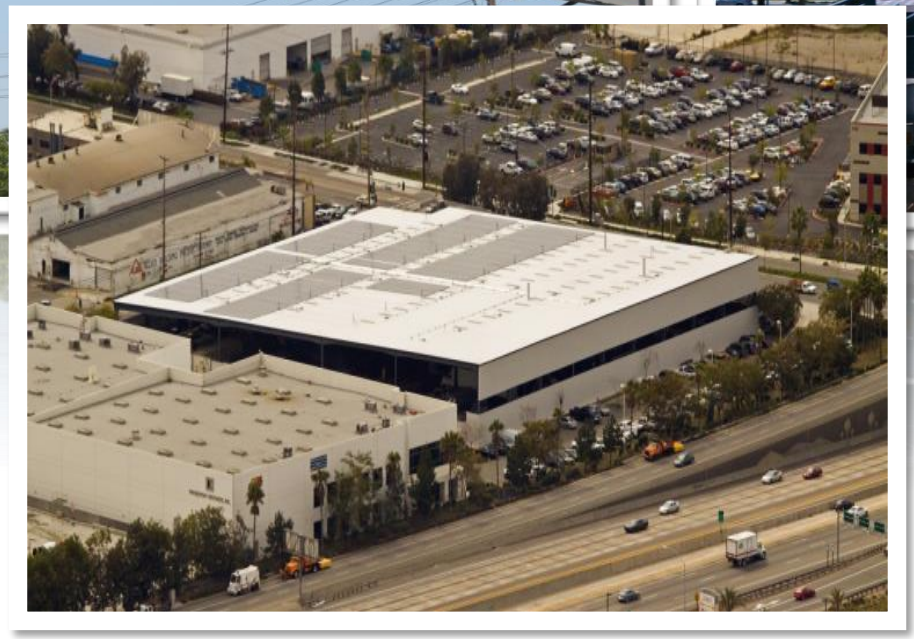
History

- 1957 Kinsbursky Brothers is incorporated in East Los Angeles on a 30,000 ft^2 facility.
- Part B permitted capacity 12 M pounds of batteries per month.
- Shared corporate headquarters for KBI and Retriev Technologies.

- 1977 Business relocated to Anaheim where it remains today.
- 1989 Kinsbursky Brothers becomes the first and only permitted battery recycling facility in California.
- Today KBI is currently renewing their 3rd Part B permit.

In 2010 KBI installed a solar array.





Provides clean energy for all of the recycling operations.

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History

1993

Retriev developed the 1st commercial facility to recycle primary lithium batteries. This hydrometallurgical process converts contained lithium metal to lithium carbonate.

1995

Purchased 65 million pounds of lithium hydroxide monohydrate from the US Department of Energy. Established Ohio operations.

1997

Awarded $10 million contract by US Navy to recycle 5000 Minuteman Extended Survival Power Batteries (MESP). 580 pound lithium thionyl chloride batteries.
Most powerful battery every made.
Project completed in 2002.

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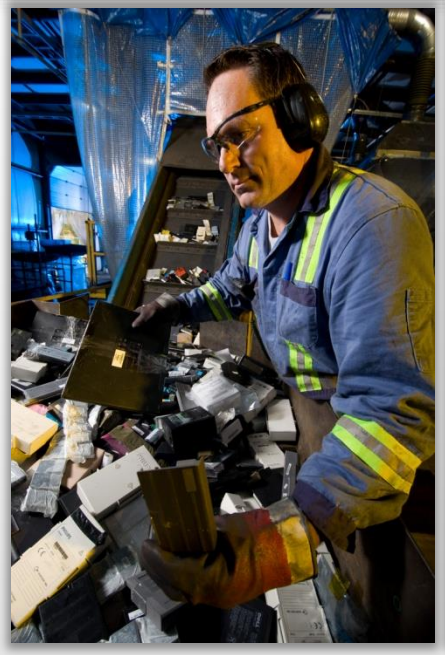
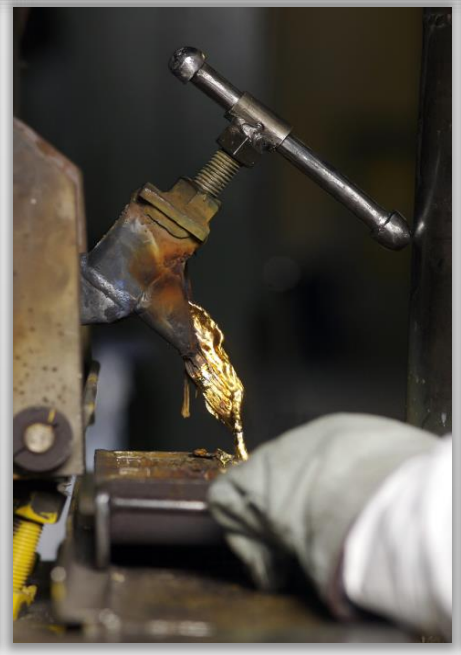
History

2002	2005	2006	2009
Launched Li-Ion battery recycling in Trail, BC.	Began Lead Acid Battery Recycling in Ohio.	Established BDAT system for cadmium containing batteries (NiCad).	Received $9.5 Million DOE grant to build dedicated facility for end of life hybrid and EV batteries.



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Trail, BC

- MOE permitted lithium recycling facility for all lithium battery chemistries:
  - Primary (non rechargeable)
  - Secondary (lithium ion)
- Annual volume: 4 million pounds lithium batteries
- 11 acre site
- 30 employees
- Produces:
  - Lithium Carbonate
  - Cobalt containing products
  - Other metal streams
    - (i.e. copper, aluminum, stainless steel)

OVER 37 MILLION POUNDS OF LITHIUM BATTERIES RECYCLED TO DATE!

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Lancaster, Ohio

DOE Funded Facility

- ❑ Part B permitted battery recycling operation since 2005
- ❑ Recycles multiple battery chemistries:
  - ❑ Lead acid
  - ❑ Nickel cadmium
  - ❑ Nickel metal hydride
  - ❑ Alkaline (household batteries)
- ❑2009 funding from DOE (ARRA)

❑Plant completed and commissed June 2015 expanding the Trail BC process

❑20,000 lbs./day capacity

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- ❑2009 funding from DOE (ARRA)
- ❑Plant completed and commissioning June 2015 expanding the Trail BC process
- ❑20,000 lbs./day capacity
- ❑Recycles manufacturing scrap, large format modules, packs, cells, and consumer batteries
- ❑Patented cathode and anode recovery technology

AGENDA

- The Changing Market

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What we thought then……

Current technology

- Market dynamics.
  - 2009 Focus:
    - lithium cobaltite
    - lithium iron phosphate
    - lithium nickel cobalt oxide
- Advanced recycling:
  - Lithium Ion Batteries
  - NiMH Batteries
  - Alkaline Batteries - Sustainability
- Battery remanufacturing
  - Automotive applications

What we know now…..

- Market dynamics have shifted
  - Multiple chemistries
  - Cottage industry growth in repurposing for ESS? and automotive applications
  - Varied content of recoverable materials.
  - At least 14 different variations.
- Multiple form factors / can be wildly diverse.
- Market perceptions have changed

Combining technologies and know how to provide solutions

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Changing the Perspective

- EOL (End of Life)Focus has shifted
  - Lower cost of ownership
  - Greener sustainability
    - Reuse
    - Regeneration of materials
- Batteries are perceived differently
  - Wireless adoption/embracement.
  - Electrification of Fleets.
  - Embedded in daily life.

Combining technologies and know how to provide solutions

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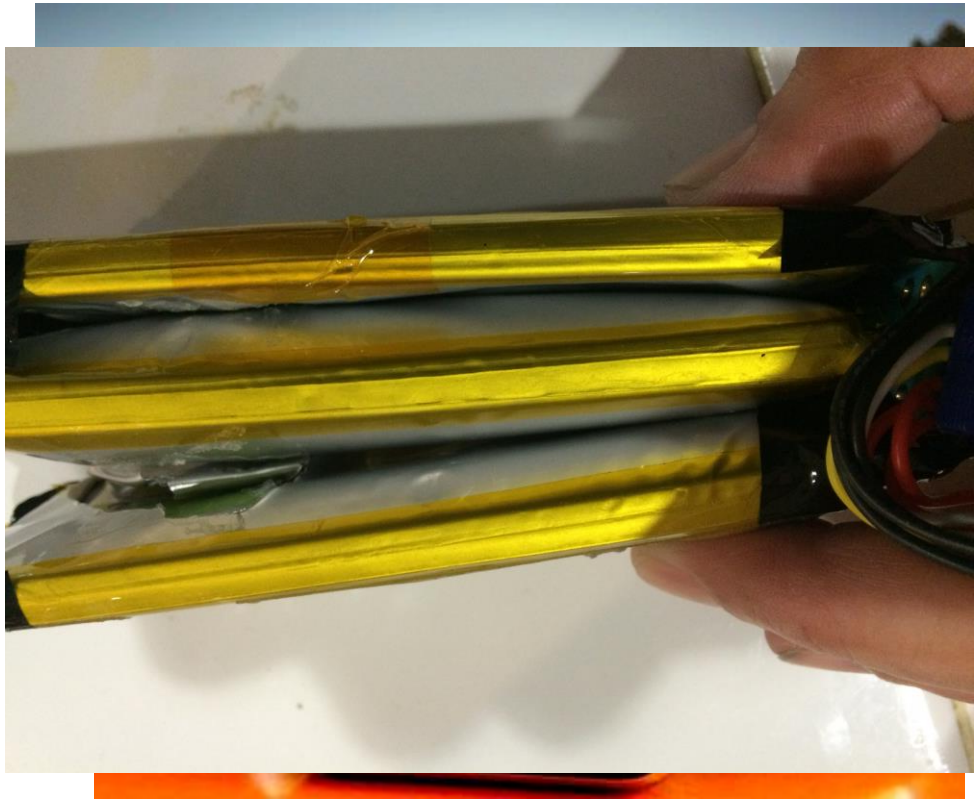
Changing the Perspective

- Lithium ion batteries are now sexy
  - Sleekly dressed up
  - Wrapped in something cool
  - Mysterious
  - What's your chemistry?
  - Some say could be dangerous



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- Path to Recycling

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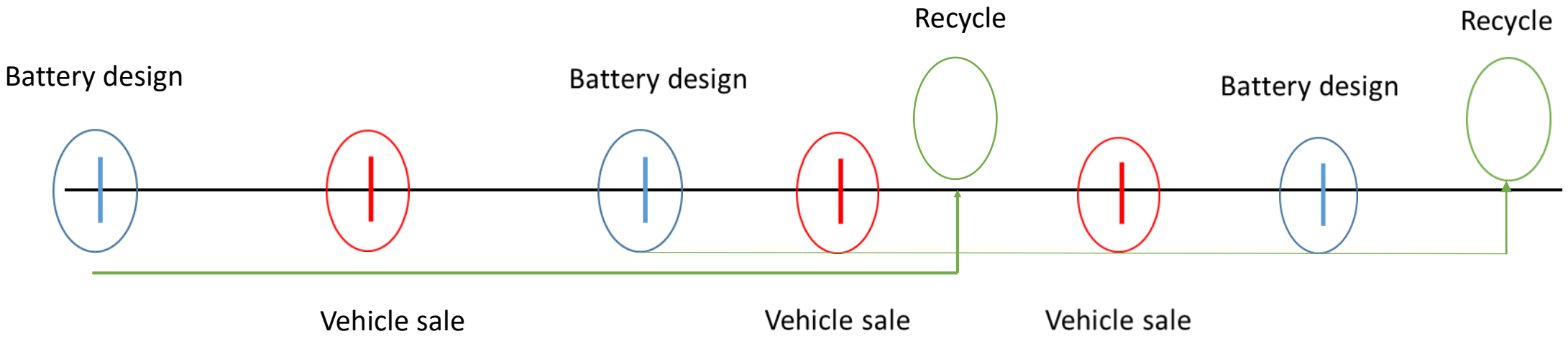
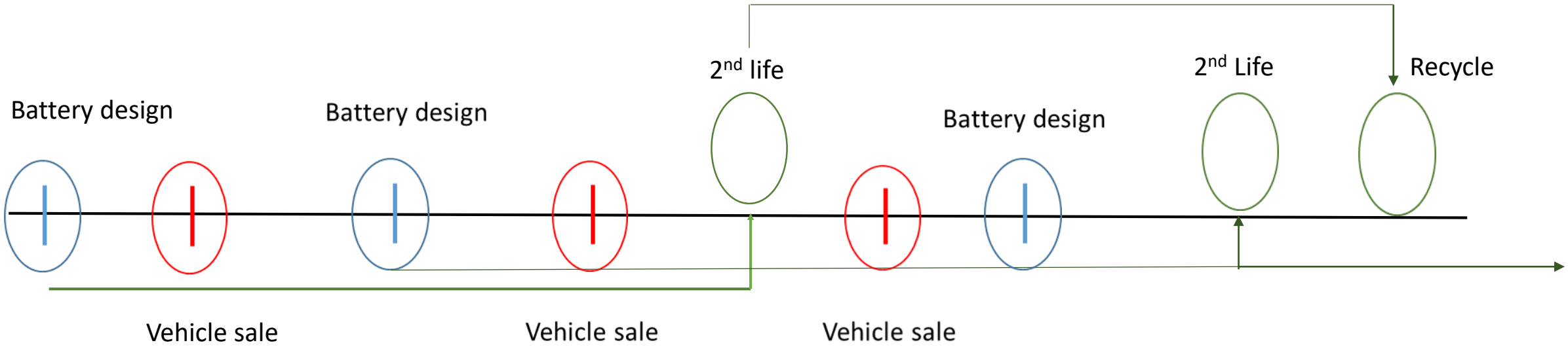
Path to Recycling



Path to Recycling



HOW IT'S DONE

Current technology

- Mechanical - Base component recovery
  - Cu, Al, Co, Ni, Plastics, & e-waste
- Hydrometallurgical
  - Solvent extraction
    - Cathode power precursors
      - Co & Ni salts
      - Li carbonate
- Pyrometallurgical
- Combination

Combining technologies and know how to provide solutions

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- Mechanical shredding of batteries in flooded chamber.
- Depending on battery, RTI may utilize liquid nitrogen to freeze batteries before shredding.
- Material is separated by screening and volumetric reduction.
- Lithium is solubilized in brine and precipitated out as lithium carbonate.

Primary lithium Batteries

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Lithium Ion Batteries

- Mechanical shredding of batteries in flooded chamber.
- Processing is independent of battery state of charge.
- Material is separated by screening and volumetric reduction.
- Metallic recovery.
- Cathode and carbon are filtered and pressed.
- Materials are sent down stream for further refining.

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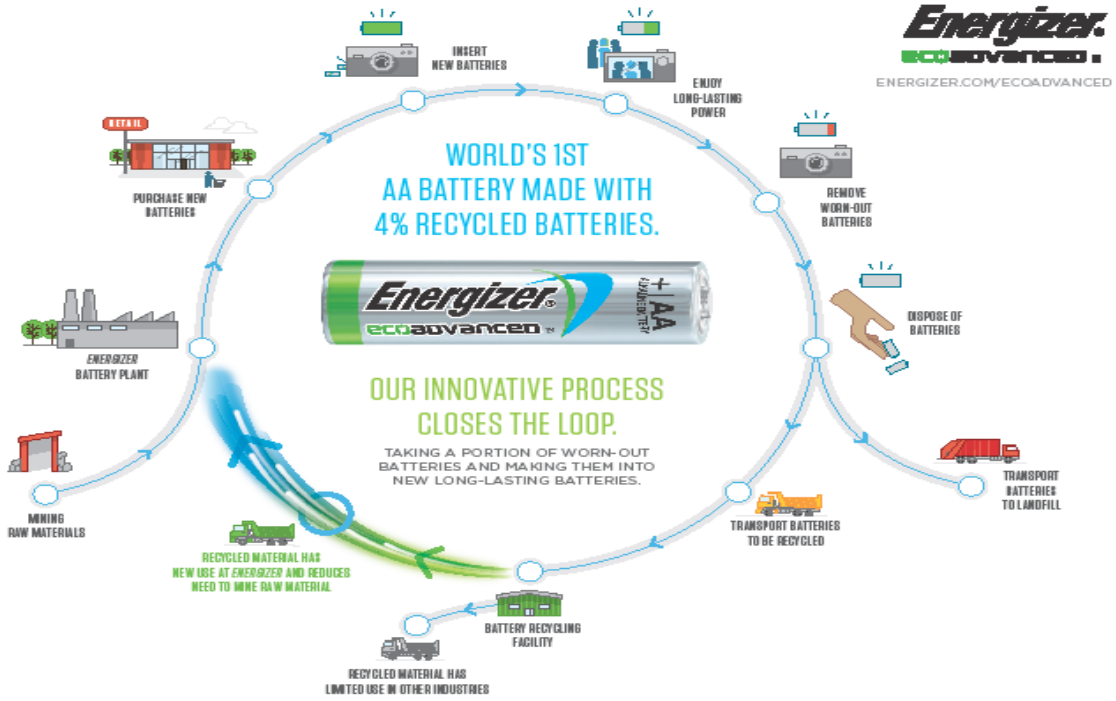
True Alkaline Battery Recycling!



- Alkaline process in full production – April 2015
- Retriev's patented technology provides a manganese dioxide raw material to Energizer
- Zinc, steel and non ferrous metals are also recovered for recycling
- Achieves a recycle efficiency >90%
- Energizer's goal is to increase the recycled manganese content in ECO advanced batteries from 4% to 40%

Path to Recycling – Roadblocks?

- New players coming into the market – Seeking materials for export.
- Growing and evolving markets
- Energy storage – Automotive
- Value/cost proposition varies depending on conditions.
- Battery materials continued evolution

- End of the stream refining may be impacted by deleterious materials.
- Regulatory complexities
  - DOT
  - EPA
  - Local/**State**
- Changing regulations
- Damaged batteries – represents challenges in the logistic chain and adds significant costs.

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- Where are we now?

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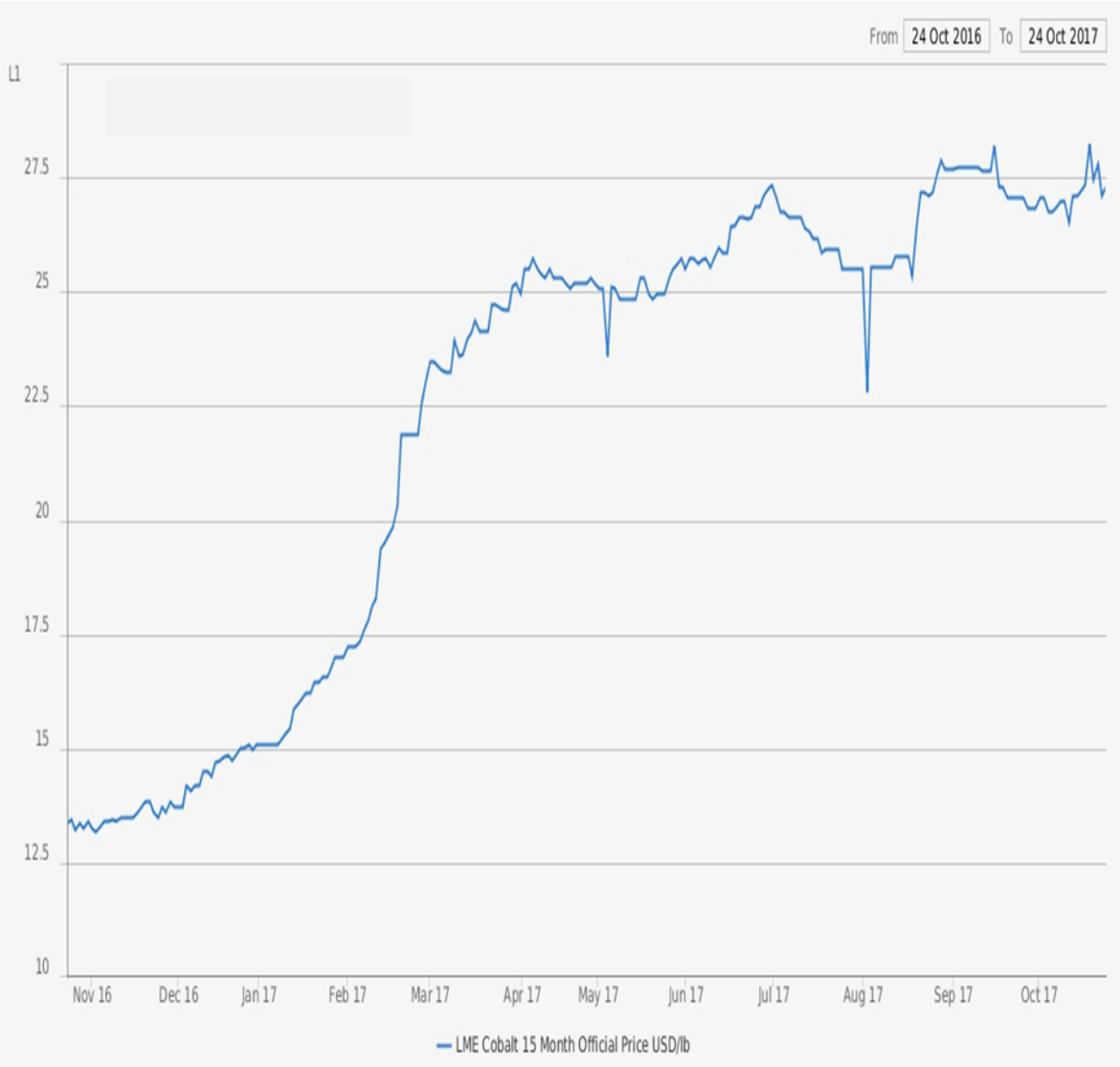
Cobalt



Nickel

Who moved my cheese?

Lithium Ion – repurposing

- Securing raw materials
- Concerns over long terms material availability and costs
- 50 - 60 % of cobalt comes from DRC.
  - Unstable conditions.
  - Supply Chain disruptions
- Global demand.
- Competing Industries.
  - Electronics
  - HEV / EV
  - Pharmaceuticals
  - Petroleum – Grease
  - Magnets
- Secondary sources (Batteries)
  - Provides access to raw materials through chemical conversion
    - Cobalt Sulfate
    - Nickel Sulfate
- Closed loop – Similar to the lead acid / alkaline battery model.

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Which Chemistry?

Lithium Ion – repurposing

- ❑ Multiple chemistries available in the marketplace
- ❑ There is no clear leader.
- ❑ Recyclers prefer cobalt containing batteries.
- ❑ Iron Phosphate creates problems in the marketplace.
- ❑ LPO4 less than 10% material received.

- ❑ Lithium battery challenges in CA.
  - ❑Regulated as hazardous waste (UW)
  - ❑No Recycling capacity in state.
  - ❑Closed loop model does not currently exist (LpO4) -> may change with volume.
    - ❑Significant investment for material without value.
  - ❑ Permitting in CA would be difficult/impossible to obtain.

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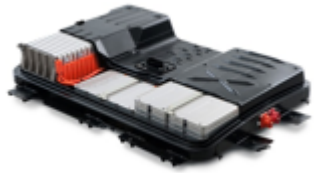
Where are we going from here ?



- Retriev has entered into an agreement with Natural Resources Canada under a shared funding program.
  - Expected outcomes are increased yields from lithium processing
  - Create a North American closed loop system for contained metals to go back into batteries.
  - Not focused on LiPO4 batteries
  - Results are expected March 2018.
- Establish partnerships for returning materials back into batteries.

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Thank You

End of Presentation